



What Can Industrial Policy Do? Evidence from Singapore

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Abstract

This article explores the limits of central industrial planning through a case study of Singapore. While previous Austrian scholars have argued that successful industrial planning is impossible, and that its successes (if any) are limited to the resolution of technical problems, the positive economic record of Singapore under the auspices of its developmental state capitalism poses a strong challenge to these market-oriented perspectives.

In response, I present a modest position. I concede that Singapore’s industrial policy has to some extent contributed to genuine economic development but insist that its state-heavy approach has nonetheless hampered the market’s entrepreneurial discovery by stifling local entrepreneurial talent and crowding out local small-medium enterprises. The top-down model has also limited the economy’s adaptive potential. I draw from productivity, entrepreneurship, and innovation data to make my case and conclude that Singapore’s experience with its developmental state model comes with a significant cost, notwithstanding its impressive achievements.

Keywords industrial policy · developmental state · knowledge problem · market process · Singapore

1 Introduction

Industrial policy has recently surged in popularity, after having initially fallen out of favour in the late 20th century. The Biden administration, soon after being elected, announced a series of industrial policies to “counter China” (Ip, 2021). European countries have also set forth their industrial strategies, which feature the aim of environmental sustainability, beyond mere economic growth (UK Government, 2021; European Commission, 2020).

Many proponents of industrial policy defend their case by referring to the successful development experience of East Asian nations in the 20th century, who made use of a

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“developmental state” model of development. Developmental states make industrial policy front-and-centre in their policy agenda, establish numerous state-owned enterprises, possess high levels of state capacity, and rely on performance legitimacy—as opposed to the democratic legitimacy typical in developed nations—in their effort to remain hegemonic (Haggard, 2018). This school of thought advanced by the developmental state theorists argue that East Asian growth experience succeeded not despite, but because of governments deliberately avoiding neoliberal prescriptions and strategically intervening in markets through industrial policy (Wade, 2005, 2018; Amsden, 1994). While some dismiss the East Asian model as a historical relic, there has been resurgent interest in the developmental state model in academe today, under the popular banner of the “entrepreneurial state” (Mazzucato, 2018; Wennberg & Sandström, 2022).

Significantly, the case of the city-state of Singapore fuels much of this interest. This is largely because while other East Asian nations like South Korea, Taiwan, and Japan abandoned some former aspects of its developmental state model, Singapore has remained steadfast, and is today considered the last remaining, yet extraordinarily successful developmental state. Many of its leading advocates refer to the Singapore case as evidence of the possibility of successful development planning (Lin & Vu, 2017; Esteban et al., 2013, pp. 585–589; Coyle & Muhtar, 2021; Rodrik, 2006; Weiss, 2016). The recently published *Oxford Handbook of Industrial Policy* hails Singapore as a paragon of the “mission-oriented” and “smart” industrial policy argument by Mariana Mazzucato (Rasiah, 2020). The leading advocate of industrial policy today, Chang (2013, p. 33), considers Singapore’s use of industrial policy to be the “most successful” amongst developed countries. So successful and blatant was Singapore’s use of industrial policy that it was an “effrontery to all kinds of economics”, mainly, the neoliberal ideas that Chang (2011a) sought to refute.

Thus, the apparent success of Singapore’s industrial policy seems to contradict the argument by Austrian economists that successful central economic planning is impossible. The Austrian argument against planning can be summarised as follows. Due to the knowledge problem, it is difficult for bureaucrats to successfully pick winners and losers ex-ante and direct the economy. Additionally, on an ex-post level, even the apparent successes of industrial policy (to the extent these may be observed) simply reflect the resolution of technical problems, and not the central economic problem. Whatever positive results planning brings forth are by themselves insufficient evidence of planning’s efficacy. I argue that such a stance is hard to sustain in the face of Singapore’s successful economic record and widespread use of industrial policy, both of which most scholars do not dispute. Even market-oriented scholars, while maintaining the merits of a market-led path to development more generally, concede that the Singapore case is an outlier (Holcombe, 2018, p. 275).

Singapore’s institutional arrangements, specifically its state-market configuration, largely resemble that of the developmental state model. Thus, the Singapore state’s use of industrial policy does not exist in a vacuum, but is conducted in a synergistic way across a range of policy domains (e.g. infrastructure building, human capital development, venture capital partnerships, etc.) to continually restructure its entire economy. It does not resemble the industrial policy elsewhere of merely ‘picking winners and losers’. Singapore’s industrial policy is carried out under a range of institutions and mechanisms constructed to resist rent-seeking pressures and to

incorporate market knowledge. Industrial policy proponents see Singapore as having fulfilled the conditions for the ideal implementation of industrial policy. Singapore is thus the “best-case scenario” justifying industrial policy.

This article will draw from Austrian insights to explore the limits of a state-led path to development. While I concede that industrial policy can theoretically be successful in generating economic development if its idealised conditions are met, it will unfortunately hamper an economy’s innovation. By eschewing a market-led path to development, industrial policy crowds out private entrepreneurs and keeps them dependent on state benefits, thereby stifling the entrepreneurial discovery process which is integral to innovation. I substantiate this argument with reference to empirical facts from the Singapore case. I show that Singapore’s developmental statism implemented human capital policies that stifled entrepreneurship and that the over-reliance on foreign multinationals crowded out small local firms, thereby limiting its innovative and adaptive potential.

Therefore, my argument on the possibility of successful development planning is a relatively modest one. My account concedes to the insistence of developmental state theorists that a) the constraints of successful implementation can be minimised by careful policy design and that b) Singapore has experienced genuine economic development through its consistent use of industrial policy. Indeed, Singapore’s heavy use of industrial planning did not lead to the widespread miscoordination and exclusion of consumer welfare as expected and which were evident in cases like the USSR. Yet, my account also reveals the costs of such an approach, in terms of the sacrifice of entrepreneurial innovation. Thus, in contrast to the conventional Austrian argument, successful planning may be possible (albeit in very limited circumstances) but comes with a sacrifice of higher-order development aims of productivity, entrepreneurship and innovation. Accordingly, I will show that Singapore’s practice of state capitalism has harmed the achievement of these aims.

While some may dismiss Singapore an outlier case not worthy of further investigation, I insist otherwise. As mentioned above, Singapore’s economic record provides inspiration for governments aiming to implement industrial policy and justification for its academic proponents. China, which some estimates already show to be the largest economy in the world, has borrowed liberally from Singapore’s state-led capitalism (Ortmann & Thompson, 2020). Considering its growing influence on the world stage, topics of industrial policy, state-led capitalism, and specifically Singapore’s role in this picture is worth further reflection. By stress-testing the Austrian argument about the limits of development planning with the “best-case scenario” of Singapore, one may derive a better understanding of what industrial policy can and cannot achieve.

2 The Knowledge Problem and Central Planning

The knowledge problem is a key theme in the Austrian School of Economics. On one level, this forms the starting point of economic inquiry. The central problem confronting any economy is not resource allocation but coordinating the plans of individuals who individually and subjectively hold dispersed bits of knowledge

(Hayek, 1945). Much of mainstream neoclassical economics either assume the presence of perfect information or blame the market for failing to attain such an ideal state. Where the lack of information is being discussed, it is typically done through a “search cost” lens, as opposed to the Austrian insistence on radical ignorance. From an Austrian perspective, ignorance is simply an economic reality, which necessitates institutions that facilitate knowledge transmission and entrepreneurial discovery.

The knowledge problem has far-reaching political economy implications, and cautions against efforts of central economic planning. This can be understood with reference to the twin aspects of the knowledge problem that Kiesling (2015) clearly elucidated: the ‘complexity’ as well as ‘contextual’ knowledge problems. These problems frustrate efforts to centrally plan the economy.

2.1 Ex-Ante Knowledge Constraints and Unintended Consequences

First, successful economic planning is impossible due to the complexity of aggregating the necessary knowledge. Rational economic calculation is impossible absent the market institutions of private property, prices, and profit-loss (Mises, 1920). Socialist economies, by removing the price system and thus its epistemic properties, have no means of rational economic calculation and lack the information signals needed for economic coordination. Hayek further extended this argument by emphasising the contextual nature of economic knowledge, that much of it exists within market rivalry itself (Boettke et al., 2016). Since planners are not market participants, they lack the requisite knowledge to successfully plan the economy.

Austrian arguments against planning have also been extended to cover non-comprehensive forms of planning. Lavoie (1985, p. 95) argued that since the planning agency remains less knowledgeable than the system it seeks to guide, its efforts to plan, even if non-comprehensive, is tantamount to “blind interference”. Thus, when applied to the specifics of industrial policy, things seem cut and dry. Even though industrial policymakers are not operating a socialist economy, they lack the necessary information—generated in the context of market pricing—to pick winners and losers. It is difficult to know *ex-ante*, what technologies and industries will be successful. Unintended consequences follow. These difficulties occur on top of related public choice problems which include political capture, rent-seeking, inefficiency, and resource wastage (Shin, 2010; Goldstein, 2007; Pack, 2000; You, 2005; Tella & Ades, 1997; Gustafsson, 2020). Admittedly, the history of industrial policy is indeed replete with such failures.

Such an argument, which focuses on the possibility or likelihood of state failure, may struggle to account for the times where industrial policy does succeed. Clearly, even the Soviet Union did witness the birth of certain successful industries, most obviously its space program. East Asian nations’ experience with industrial policy led to the establishment of now famous brands such as Samsung, Hyundai, and Toyota (Kuk, 1988; Magaziner, 1981). Singapore’s industrial policy is even more vaunted and is credited to have propelled it from third world status to first (Lee, 2012; Lee, 1973).

2.2 Ex-Post Evaluation of Industrial Policy

Of course, Austrians have a response to the alleged successes of industrial policy. This response focuses on the problems with the *ex-post* evaluation of government intervention. There are two related strands of this argument. First, even if industrial policy can deliver successes, these successes do not resolve the fundamental economic problem. Skarbek and Leeson (2009) made this argument in relation to foreign aid, acknowledging its many successes, yet showing that aid cannot contribute to economic growth since it does not resolve the deeper economic problem of attaining efficiency across a multitude of ends. Second, even if industrial policy ostensibly contributed to “economic successes”, one does not know what would have occurred had industrial policy not been used in the first place. The same economic achievements may very well have occurred if a market-led path to development was opted for in the first place.

Powell (2005) criticised the East Asian success story on precisely these grounds. He argues that industrial policy proponents reduce economic development to the technical problem of simply investing resources to foster successful industries. Planners do not enjoy the counterfactual knowledge needed to evaluate industrial policy’s success, that is, they do not know the “opportunity cost of another industry’s potential use of the resources” (Powell, 2005, p. 308). If government had not used industrial policy, another firm might have enjoyed more resources. The firm or industry being supported may also emerge spontaneously anyway in the market context. Since there is no way to obtain such evaluative information, one cannot conclude that planning was a success, even if one observes firms and industries that become profitable due to government support. This argument has much force, because it means that the results generated by planning, even if positive, “are not ever proof of planning’s success” (Powell, 2005, p. 311).

In addition to this *ex-post* aspect, Powell (2005) adds an extra layer to his position by insisting that development in East Asia was overstated because most accounts focused on industrialisation rather than genuine consumer welfare. He also adds that in fact, many East Asian nations were in fact economically free according to indices of economic freedom.

While theoretically sound, such arguments may not be the most convincing. Of course, there is no way to properly evaluate the opportunity cost of industrial policy. Austrians are right to claim that successful economic development entails the ability to *retroactively assess* whether resources were used in the most efficient way. The challenge involving industrial policy is that there is no way of knowing *ex-post*, whether the funds invested by the government were indeed used well. In a world of nation-states, this problem is unavoidable. Since states impose singular decisions on society, there’s no way to access the counterfactual information needed to assess whether conditions would have been better absent the state’s interventions (DeCanio, 2021).

Proponents of industrial policy and the developmental state are aware of this problem. They accept the truism that the success of industrial policy cannot be proven and instead focus on the plausibility of developmental narratives. Chang (2011b) responds that even though it cannot be proven, the industrial policy success narrative is more plausible than its neoliberal counterparts holding that the economy

would have been better off under a market-led model. Thus, the argument cuts both ways. Just as industrial policy advocates cannot prove the superiority of industrial policy, market advocates also cannot prove likewise for the market-led model.

More importantly, the main issue for industrial policy theorists is not about knowing whether the use of resources was indeed efficient, but whether the results of the policy led to structural transformation of the economy to higher value-added activities. Many countries that utilised industrial policy witnessed the birth of successful firms and competitive industries, which in turn led to higher welfare for citizens (Labory & Bianchi, 2020; Reinert, 2020). Industrial policies have arguably been able to catalyse structural transformation, moving economies out of agricultural industries into the industrial world, and from low-value added industries to higher-value added industries (Mazzucato, 2018). If these objectives are achieved, the inability to retroactively ascertain if government intervention was most efficient or not seems irrelevant.

If the subjects of East Asian developmental states have enjoyed high and rising living standards over time, then that is arguably the more salient issue. Indeed, they have. Many East Asian nations did enjoy genuine economic development which cannot be reduced to mere industrialisation. While it may be possible to say that the Soviet economy's industrialisation drive failed to resolve the fundamental economic problem, it is hard to sustain this argument for East Asia. While it is beyond the scope of this paper to fully review the empirical details of Asian standards of living, it is widely accepted that residents of East Asia are the most well-off in the world (Lall, 2006).

Singapore does not simply enjoy high incomes, but also fares among the best in numerous aspects of standard of living. Singapore's recent 14th rank on the Legatum Prosperity Index (2021) is sufficient proof. One may of course dispute whether industrial policy was instrumental to these achievements. Yet, a large literature exists that links the developmental state's use of industrial policy to the successful restructuring of its economy to higher value-added industries, which in turn allowed the state to secure better jobs for its residents, remain at the technological frontier, and improve its public services (see Oqubay et al., 2020). Pro-planning scholars on Singapore's political economy link the country's use of industrial policy to several positive outcomes: a competitive investment environment, an attractive financial destination, and the abundance of highly-skilled human capital and productive enterprises (Chia, 2005; Peebles & Wilson, 2002; Ho & Yun, 2011; Wang, 2016; Lim, 1995, 2016, pp. 17-49). Such achievements go beyond "picking winners and losers".

Powell is right to look at genuine consumer well-being and not just incomes. However, it is hard to sustain the argument that East Asian nations do not enjoy high levels of ownership of quality consumer goods. It is largely taken for granted that Singapore is a consumer's paradise (Chua, 2003). Even in the 1980s, when industrial policy was being accelerated, its consumer living standards were one of the highest in the region (Swee & Chin, 1985; Singh et al., 1996). It has world-class healthcare, infrastructure, transport, education, etc., much of which involves a high degree of state planning that far exceeds the classical liberal ideal.

It may be said, however, that such achievements came about through economic freedom. After all, Singapore is one of the economically freest nations in the world, according to available indices. This is, however, highly misleading. While a full review of economic freedom indices is not possible here, it suffices to say that most

local area experts on Singapore's political economy agree that Singapore's economic freedom has been systematically overstated. Virtually all East Asian scholars show how the Singapore state is one of the most intrusive in the world, both economically and socially (Lim, 1983; Krause et al., 1990; Chua, 2017). According to Lim (1983), a leading Singaporean economist, "what has made Singapore successful is not the Invisible Hand of the free-market, but rather the very visible hand, indeed the Long Arm, of the state". Singapore's government is well-known for its intrusive social engineering of private lives, authoritarianism, disciplining of civil society, and large presence in state-owned enterprises, and industrial policy—surprising features for the supposedly "freest economy" (Chua, 2017).

3 Singapore and the Developmental State Framework

While Singapore is nominally a capitalist country, its state-market arrangements fit within the analytical category of the developmental state variant. This arrangement is distinctive in its heavy use of industrial policy and unique configuration of the state. The developmental state enjoys a high degree of state capacity—being able to shape the actions of private actors according to its will—and relies on strong economic performance to sustain political legitimacy, i.e., performance legitimacy. State capacity is employed to heavily mould public opinion, social mores, and practices. Understandably, developmental states tend to be authoritarian, and this is justified—and in most cases accepted by the public—as necessary to achieve the single-minded national solidarity necessary for economic growth (Haggard, 2018; Chu, 2016). Its unique configuration affords the developmental state significant control—not just physical, but also informal—over private actors, in ways difficult to capture in aggregate statistics.

Thus, even though Singapore is technically a capitalist economy, it exhibits many of the unique institutional characteristics of the specific developmental state 'variety of capitalism'. An important trait of the developmental state is "embedded autonomy", which is a paradox: it enjoys close connections with private actors but is nonetheless shielded enough to withstand private interest group pressures (Evans, 2012). Arguably, Singapore's industrial policy does not seem to resemble the many egregious cases of inefficiency, resource wastage and state failure seen elsewhere. This is largely attributed to its careful policy design to minimise potential incentive and knowledge problems. Incentive problems are minimised by establishing institutional mechanisms to ensure programs are time-limited, regularly reviewed and transparently administered (Ma, 2000; Haque, 2004). At the heart of this system is a civil service that is public-spirited. While this may seem like a utopian fantasy to Western observers used to special interest politics and political capture, the Singapore public service has been positively-praised in most quarters and has captured the admiration of the international community (Saxena, 2011). Knowledge problems are also minimised by devolving some authority such that industrial subsidies are evaluated by various state-affiliated but autonomous bodies. Venture capital and business experts are invited to work with the state on joint projects and co-administer industrial programs. Rather than crudely "picking winners", the developmental state adopts a consultative approach vis-a-vis businesses, garnering the necessary

knowledge in its industrial policy design (Centre for Liveable Cities, 2017). Sovereign wealth funds focus investments on firms with a positive record, to promote commercial discipline, though this means that only more established firms receive state attention. Ultimately, the attraction of a developmental state is that it can judiciously steer market forces and minimise state failure.

The institutional arrangement of the developmental state by no means fully overcome the incentive and knowledge problems of industrial policy, which are numerous (Karlson et al., 2021). Yet, the mechanisms employed by this framework have contributed to a positive record of industrial policy in Singapore.

4 Entrepreneurial discovery, capital complexity and adaptation

Contrary to the claims of developmental state advocates, economic development can be achieved from the bottom-up, in a process driven by entrepreneurs. These entrepreneurs play a critical role in discovering new production techniques and products, and in so doing, facilitate economic development. The contribution of entrepreneurial discovery to development can be better elucidated through two key concepts: ‘capital complexity’ and ‘adaptation’.

At the most basic level, economic development requires capital accumulation. Despite disputes over the proper ends of development, there is general agreement that it involves at minimum greater material production, without which a variety of other ends cannot be pursued. In turn, the degree of material production in any economy is amplified by the investment in capital goods. Economies with high levels of material production employ more “roundabout” production processes rather than the rudimentary production processes seen in under-developed societies. For example, while hunter-gatherers live a hand to mouth existence, products in modern societies are obtained by consumers at the end of many stages of production involving capital goods like tools and machines (Lewin & Baetjer, 2015, p. 146). The increasing number of production stages in an economy indicates the growing complexity of an economy’s capital structure.

Additionally, a developed economy’s capital structure is not a homogenous stock but a complex arrangement involving numerous stages of production, with complementary capital goods employed in a variety of production processes. Following this, economic development can simply be understood as the *process by which an economy achieves growing complexity in its capital structure* with more stages of production, or, as portrayed by Lachmann (1978, p. 85), “an ever more complex pattern of capital complementarity.”

The concept of ‘complexity’ in the capital structure highlights the flaw of early development economics, which did not realise that capital is heterogeneous and multi-specific. Capital goods are not alike, with each having “multi-specific uses”, able to fit into diverse production plans (Lachmann, 1978, p. 2). Thus, developing economies do not simply need more capital investment, but capital that complements the existing structure of production. According to Powell and Manish (2015), the twin characteristics of capital heterogeneity and multi-specificity means that economic coordination is crucial to align the capital structure to meet the most valued consumption plans. Therefore, the contribution of the market process to development is not a blind accumulation of capital but the coordination of rival production processes.

Accordingly, economic coordination occurs dynamically and is driven by entrepreneurs who play a central role. They are the driving force of the market economy (Mises, 1949, p. 248). Within the context of market rivalry, entrepreneurs make use of localised and often tacit bits of knowledge, trying out different production plans and product offerings. Crucially, they operate and make decisions under conditions of uncertainty (Foss & Klein, 2012). The profit-loss mechanism then provides firms with crucial feedback regarding the relative success of alternative plans. This constitutes a dynamic process of trial-and-error learning where entrepreneurs will discover better capital combinations and product innovations to meet consumer desires (Kirzner, 1985, p. 68-92; Hayek, 2002). Besides achieving growing complexity in the capital structure, the entrepreneurial discovery process also leads to the improvement of product quality and the emergence of new markets (Holcombe, 2007). Thus, innovation is not simply a by-product of development, but is core to the Austrian story of development.

In the context of innovation, entrepreneurs do not always engage in radical breakthroughs à la Schumpeter. Entrepreneurs in the market process are typically Kirznerian entrepreneurs, who discover profit opportunities and equilibrate markets. Instead of developing revolutionary breakthroughs, their strategies are usually imitative, incremental, and localised, launched by small firms (Yu, 1997). While the individual contributions of Kirznerian entrepreneurs may be modest, they are significant because they contribute to adaptiveness at the system level. Thus, Kirznerian entrepreneurs are also called adaptive entrepreneurs (Yu, 2001). They adapt to changing conditions and continually revise their plans, thereby generating economic change.

The market, if allowed to operate spontaneously, is a complex adaptive system. Adaptability is especially important if innovation-driven development is the aim of economic policy. This is due to the reality of radical uncertainty in the innovation landscape, where future breakthroughs and economic trends are difficult to foresee in an increasingly volatile, uncertain, complex, and ambiguous ('VUCA') world. While the state faces a knowledge problem in forecasting economic developments, the market process overcomes the problem by recalibrating itself in light of new circumstances. The implication therefore is that policy should focus on ensuring the general conditions for such adaptive economic adjustments, rather than directing entrepreneurship or economic activity. The problem in the Singapore context, as will be shown, is that the state decided to play a 'directive' role in entrepreneurship, hindering the market process and its adjustments.

5 Weak Innovation

Even though Singapore has generally achieved high employment and national income, it has not fared as well when it comes to entrepreneurial innovation and the productive use of resources. As explained above, market entrepreneurs respond to information and incentives, and in the process, find the most efficient ways to make use of resources. In the case of Singapore, growth has proceeded based on the raw

accumulation of factor inputs, rather than the intelligent use of resources characteristic of market processes. I will utilise three indicators in this section to buttress my claim and make a comparison with Hong Kong, Singapore's economic twin.

The first and most important indicator to use is that of total factor productivity (TFP). According to the Solow model, TFP reflects a nation's holistic innovation performance. Here, we may compare Singapore's historic performance against that of Hong Kong up till 1997, when Hong Kong's handover to China caused it to lose its liberal distinctiveness (Fig. 1).

The presented data supports the argument that state intervention has limited Singapore's economic performance. Every year in this 33-year period, when Hong Kong maintained its *laissez-faire* tradition, its TFP was consistently higher than that of Singapore. Industrial policy if successful, should enable a country to achieve higher scores. Yet Singapore's scores remained lower than Hong Kong's, where such intervention was non-existent. What is even more surprising is that in 1997, just when Hong Kong was about to be handed back to China, Singapore's TFP of 0.658 is still worse than Hong Kong's lowest TFP of 0.695, three decades earlier in 1964.

Singapore's TFP dip in the mid-1980s also supports my thesis. This was largely caused by a structural (rather than cyclical) recession, the only time in Singapore's history when its domestic economy contracted while the global economy grew. Experts acknowledge that this resulted from dissipation of earlier cost advantages and the setting in of diminishing returns to (mainly foreign) investment (Menon, 2015; Rodan, 1989). The 1979 'Second Industrial Revolution' plan unintentionally lowered productivity because it artificially raised unit costs through central wage setting (Rigg, 1988). In other words, the early phase of Singapore's industrial policy 'lost steam'.

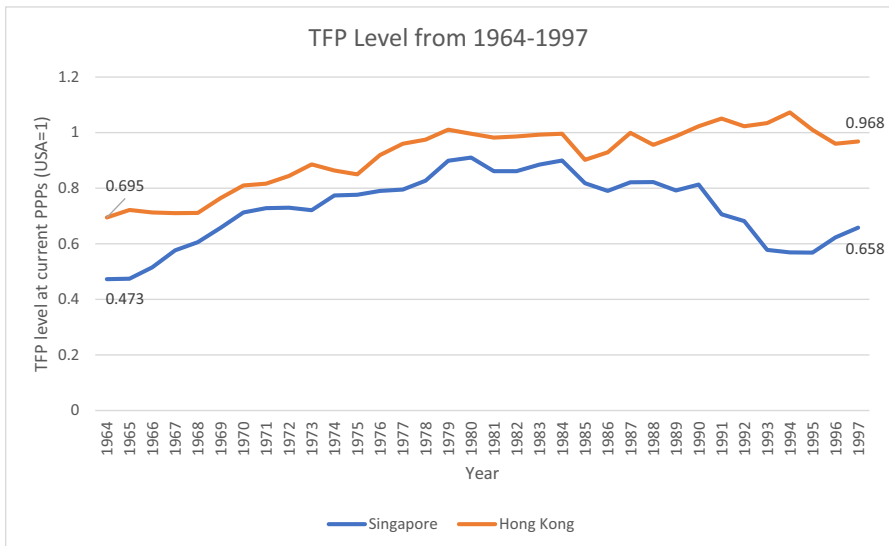


Fig. 1 TFP of Pre-1997 (Market-Oriented Period) Hong Kong and Singapore. Source: Feenstra et al. (2015).

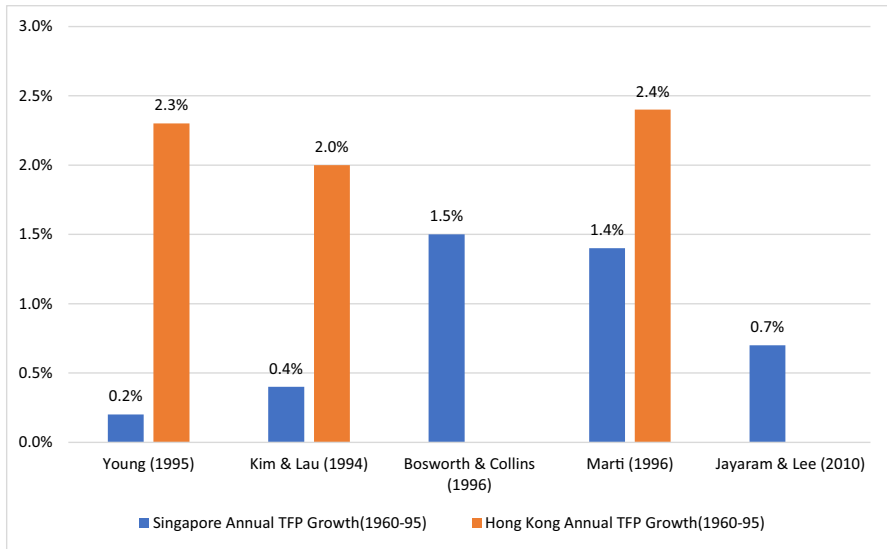


Fig. 2 Various Scholars' Historical Estimates of TFP Growth in Singapore and Hong Kong (1960–95). Source: Author's compilation.

Singapore's poor TFP is recognized by many. Despite the different methods of calculation, all leading studies show that TFP-growth played a much bigger role in Hong Kong's development than in Singapore which fared worse than other Asian economies until 1990 (Fig. 2).

The second indicator is patent data over the same pre-2000 period. Here, I present patents filed in the United States Patent and Trademark Office (USPTO), which reflects higher commercial importance due to the tech-intensive nature of the US market.

Even though the figures show that Singapore had a larger overall increase in patents registered from 1976 till 2019, the data supports my argument that developmental statism stifles innovation. This is understood by distinguishing the two time periods involved. Singapore only overtook Hong Kong in the early 2000s ('Later Phase', Appendix 1), eventually eclipsing Hong Kong in recent years. The critical juncture that marks this turning point is Hong Kong's 1997 handover, after which Hong Kong started abandoning its *laissez-faire* past and began emulating Singapore's industrial policy. Therefore, in the 'Early Phase', when institutional differences between Singapore and Hong Kong were greatest, market-oriented Hong Kong outperformed statist Singapore, despite providing less support for innovation (Fig. 3).¹

The third concept to consider is that of 'innovation efficiency', which is whether innovation inputs are translated efficiently into outputs. This is a crucial indicator because a nation's performance on aggregate innovation indices may be artificially inflated due to government spending on R&D. Even though Singapore ranks highly on global innovation indices, closer scrutiny reveals

¹ Post-2008, Hong Kong's economic recovery was muted, largely due to its domestic problems and uncertainty over its status within China, which partly explains its lag recent years.

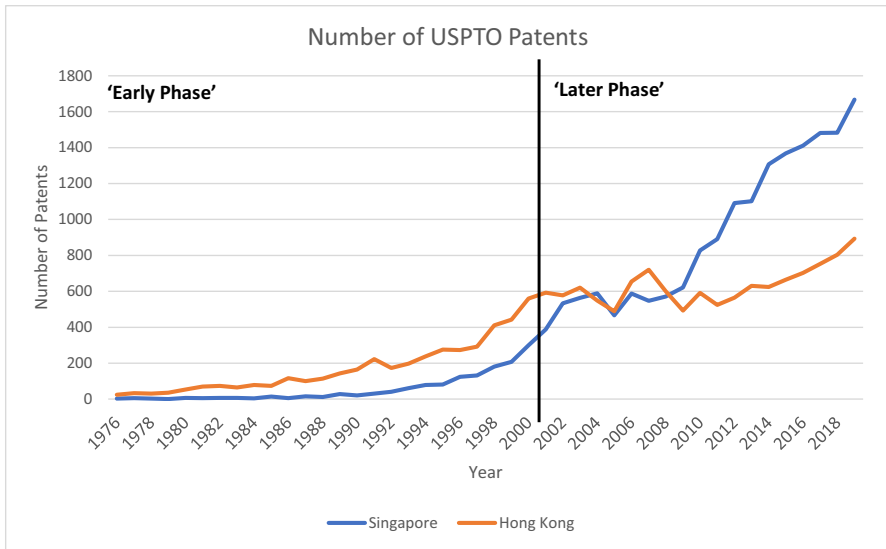


Fig. 3 Number of USPTO Patents filed by Singapore and Hong Kong Inventors. Source: United States Patent and Trademark Office (2020). Appendix 1.

that it scores poorly on the sub-component of innovation efficiency. A recent edition of the Global Innovation Index, using a global comparison, declared that “Singapore produces less innovation outputs relative to its level of innovation investments” (World Intellectual Property Office, 2019, p. 3). This suggests that the top-down approach to innovation in Singapore has not fetched the corresponding results in terms of commercialisable outputs. This is further corroborated by the only edition of the Creative Productivity Index in which Singapore is the worst-ranked Asian country. Even though Singapore scores the highest in inputs—a logical result of heavy government investment—these investments have not translated efficiently into the corresponding outputs (Table 1).

Table 1 Comparison of Asian Countries Ranked in Top 10 of Creative Productivity Index in 2014

Country	Overall	Input	Output
Japan	1	8	4
Korea	3	9	8
Taiwan	5	7	9
Hong Kong	7	2	2
Laos	9	23	17
Singapore	10	1	6

Source: Asian Development Bank and Economist Intelligence Unit (2014)

6 Why Singapore struggles with innovation-led growth

The Singapore developmental state has unfortunately hampered entrepreneurial discovery so described. This is a product of two-interrelated mechanisms. First, human capital policies of the developmental state stunted entrepreneurial desire amongst locals. Second, government-linked entities in Singapore, in concert with state-favoured multinational corporations, have crowded out local small-medium enterprises. The combined result of these two mechanisms is that even though Singapore may score well on national income indicators, it fares poorly in terms of local entrepreneurship and innovation.

Normatively, it should be acknowledged that there is nothing intrinsically undesirable with a high reliance on foreign capital. Far from advancing an economic nationalist argument, what I argue is that the local-foreign mix in Singapore is not a product of endogenous market processes but was artificially engineered. This is problematic because the foreign sector, being state-supported, acts as a barrier to entry for local enterprises who do not compete on a level playing field. Additionally, the state's path-dependent reliance on foreign MNCs comes at the expense of the economic adaptiveness that SMEs can offer.

6.1 Mechanism 1: Human capital policies stunting local entrepreneurship

The Singaporean state adopted specific human capital policies that inadvertently stunted local entrepreneurship. First, the nature of its education system was geared towards the hard sciences, and more recently, STEM subjects, to generate workers with the 'right skills' to service growing industries identified by industrial policy (Tan et al., 2016). As such, the end-goal of was to obtain secure employment in specific sectors. This is not undesirable in itself, but comes with the unintended consequence of stifling individual risk-taking and creativity (Tan & Phang, 2005). This is also partly associated with the Confucian cultural preference for hierarchy in most East Asian education systems (Hairon & Dimmock, 2012; Kwon et al., 2017).

Notably, a former Education Minister remarked that Singapore's obsession with exam means that its students lack the innovative spirit inculcated by America's education system. Compared to America,

We (Singapore) know how to train people to take exams. You (America) know how to use people's talents to the fullest. Both are important, but there are some parts of the intellect that we are not able to test well — like creativity, curiosity, a sense of adventure, ambition. Most of all, America has a culture of learning that challenges conventional wisdom, even if it means challenging authority (Zakaria, 2012).

This is not to say that Singaporeans are poorly educated, but that the system is not conducive to the individual risk-taking integral to entrepreneurship.

Second, 'developmental state' theory also emphasises a reliance on high quality talent in government. It is believed that with talented bureaucrats, knowledge and incentive problems may be minimised, and effective policies enacted. In Singapore,

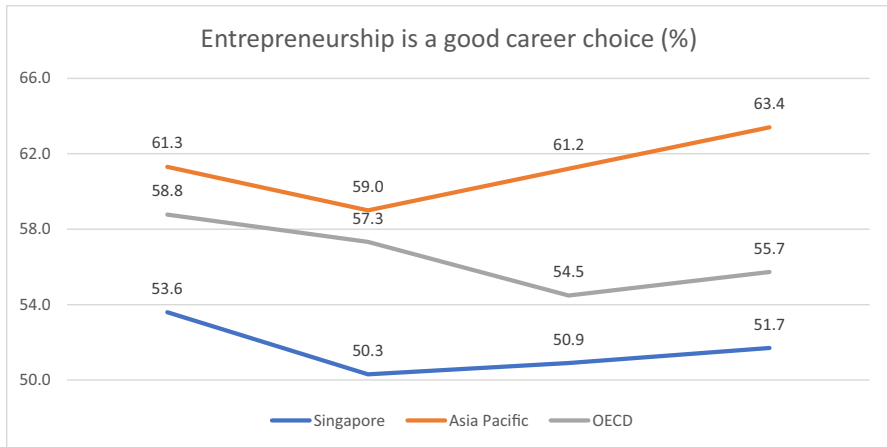


Fig. 4 GEM Responses in Singapore, the Asia Pacific, and the OECD.

this translated into the generous use of government scholarships to attract talent as well as lucrative remuneration packages for civil servants (Quah, 2010). Aside from pure monetary rewards, these scholarship recipients also typically receive high social status, and are portrayed by the media, their schools, and public institutions as ‘elite high-flyers’ (Chua & Bedford, 2016). This affects the overall risk-reward calculus of fresh graduates; why take up risky entrepreneurship if one can achieve a high status through a government career.

The evidence on the lack of local entrepreneurial desire is gleaned from several well-known sources. First, Singapore’s performance on the Global Entrepreneurship Monitor (GEM), arguably the prime study on entrepreneurship, shows that entrepreneurial desire is lacking, as compared to its Asia Pacific and OECD counterparts.² From 2011–2014, where Singapore was included in the GEM Global Study, the percentage of Singaporean employees who believed “entrepreneurship is a good career choice” or that “successful entrepreneurs enjoy high status” have consistently lagged behind that of the Asia Pacific- and OECD average (Figs. 4 and 5).

Social stigma associated with entrepreneurship in Singapore is also far more prevalent. Singapore ranks very poorly on perceived skills (how equipped you think you are) and perceived opportunities (how confident you are of available opportunities) to start a business in future. On both measures, Singaporeans scored at least 10% lower than the OECD average for all four years for which data is available. Perceived skills and opportunities are two attitudinal variables that are strongly correlated with entrepreneurship intent (Chernyshenko et al., 2015). A low ranking on these dimensions implies that Singaporeans remain relatively apathetic towards entrepreneurship (Figs. 6 and 7).

² Singapore was no longer included in the GEM after 2014.

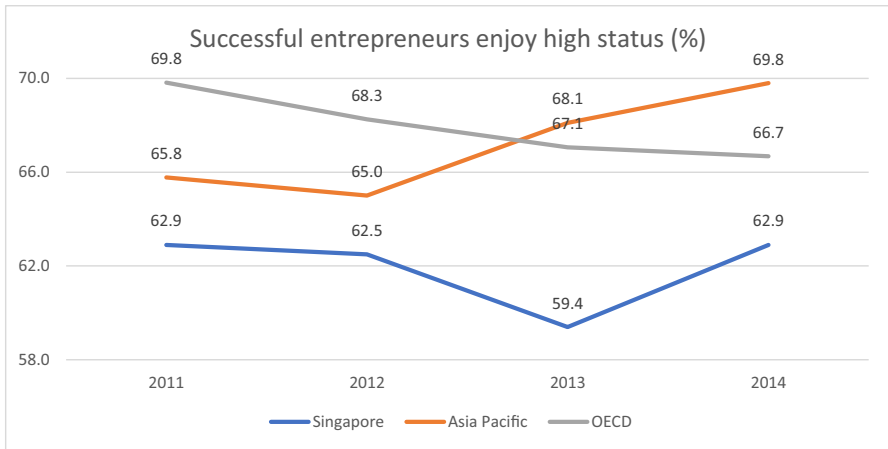


Fig. 5 GEM Responses in Singapore, the Asia Pacific, and the OECD.

The comparison with other Asian countries is buttressed by the most comprehensive survey done on youth entrepreneurial aspirations, involving 56,000 people across Southeast Asia (Seow, 2019). This survey documents the fact that Singaporean youths rank last out of six countries surveyed, with only 16.9% expressing the desire to become an entrepreneur. In a separate survey done by the Randstad Workmonitor in 2017, 73% of respondents in Singapore preferred to work for an MNC compared to just 63% and 57% of respondents who prefer to work for an SME and start-up respectively. The results bucked the global trend of employees increasingly favoring work for a SME or start-up compared to an MNC (Randstad, 2017). These results show how traditional employment remains preferable to starting a business (Table 2).

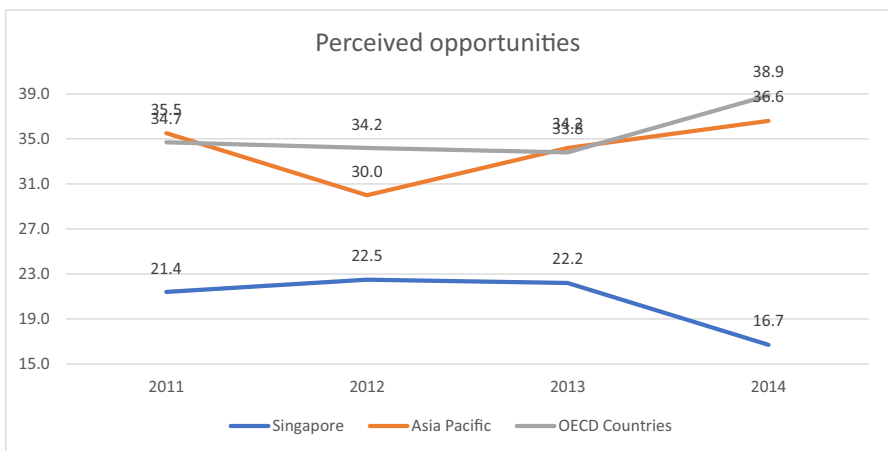


Fig. 6 GEM Responses in Singapore, the Asia Pacific, and the OECD.

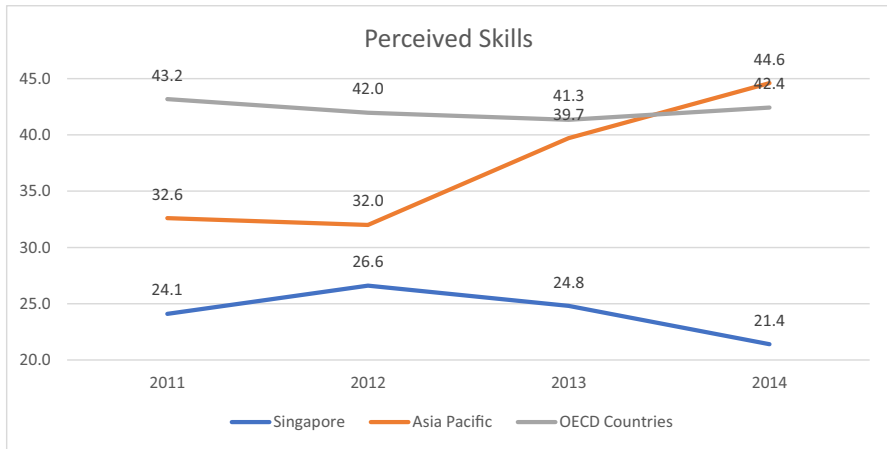


Fig. 7 GEM Responses in Singapore, the Asia Pacific, and the OECD.

As a result, there is a dearth of entrepreneurial talents in Singapore. According to Start-up Genome (2021), Singapore scored a 2 out of 10 for ‘Start-up Success’, as measured by the number of successful start-ups in the ecosystem. Even the six ‘unicorns’ that Singapore has produced (Grab, SEA, Trax, Lazada, Patsnap, Razer) were all founded or co-founded by foreign entrepreneurs (Audretsch & Fiedler, 2022). In the Start-up Genome report (2021), Singapore also performed relatively poorly in ‘quality and access’ to tech talent (2/10), research impact of publications (2/10), and local market reach, which is unsurprising since innovation activity is concentrated in foreign hands.

6.2 Mechanism 2: Over-dependence on state-MNC model hampers economic adaptiveness

Singapore’s over-reliance on MNCs is caused by state-engineering rather than market trends. This increases the entry barriers for small firms and restricts their contributions. The capacity of local firms to innovate is also neglected since all the focus

Table 2 Youth Entrepreneurial Aspirations Across Asia

Rank	Country	% of youths expressing a desire to become an entrepreneur
1	Indonesia	35.5%
2	Thailand	31.9%
3	Vietnam	25.7%
4	Malaysia	22.9%
5	Philippines	18.7%
6	Singapore	16.9%

Source: World Economic Forum (2019)

is placed on large multinationals, which poses a concern for the sustainability of the current strategy. Additionally, economic adaptiveness is also compromised. An adaptive economy is one that is resilient in the face of uncertainty. By locking itself onto an MNC-heavy path and sidelining local enterprises, the adaptive potential of the wider economy is compromised, which explains Singapore's poor indigenous innovation in the past and raises concerns about Singapore's ability to adapt to the changing innovation landscape in future.

In this section, I show how, pre-2000, the Singapore government created an unequal playing field by favouring MNCs, but began attempting to reverse this since 2000 by focusing on improving labour productivity in SMEs. I will subsequently elucidate the welfare implications of this imbalance.

6.2.1 Unequal playing field

During the inception of the Singaporean developmental state in the 1960s, it was believed that there was a dearth of domestic capital. Coupled with Singapore's small size, there was an urgently felt need to attract foreign capital. The Economic Development Board was thus established to attract multinational corporations with a slew of industrial policy incentives, including tax incentives, subsidies, government-underwritten loans, and state-funded industrial facilities. The Jurong Town Corporation was also significant; they built industrial facilities and made them available at little to no cost for MNCs. Singapore's sovereign wealth funds were also established in part to attract these firms through lucrative private-public partnerships. Since then, these MNCs have contributed greatly to Singapore's GDP and employment.

Significantly, not only were MNCs aggressively courted, the SME sector was deliberately suppressed. SMEs in early Singapore were concentrated in the trade and services sector and thus deemed unsuitable for state-led industrialisation. Additionally, numerous SME leaders hailed from Chinese-speaking communities who were the major source of political opposition to the emerging leaders of developmental state, led by the English-speaking faction of Lee Kuan Yew. This English-Chinese schism in early Singapore is complex but saw the political persecution of some of the top SME leaders in Singapore, most notably Tan Lark Sye (Visscher, 2007). Their social and business networks, prominent in colonial Singapore, were sidelined by national policy. Therefore, for both economic and political reasons, MNCs in early Singapore were consciously favoured by the developmental state's national economic plans, at the expense of local SMEs.

This MNC-led model has persisted due to political considerations, and the pro-MNC industrial policy schemes still exist today. The Singaporean developmental state is one that derives its continued political hegemony through economic performance. In the decades after independence, MNCs provided a ready source of jobs and thus economic security for the local population, ensuring the state's continued electoral success. Additionally, foreign multinationals are also closely integrated with government-linked corporations in Singapore, through many joint partnerships and the exchange of talent. Experts have explained how the Singapore state has a vested interest in perpetuating this MNC-model (Lim, 2016; Lim & Pang, 2016).

Table 3 Comparison of East Asian SMEs Value-Add and Share of Exports

	No of firms	Workforce	Value Added	Direct Exports
Taiwan	97%	70%	55%	66%
Hong Kong	98%	62%	57%	17%
South Korea	98%	66%	38%	32%
Singapore	81%	40%	22%	15%

Source: Economic Development Board (1990)

Therefore, the business landscape is not a level playing field for local SMEs. The state's preference for MNCs and generous funding to it for decades has meant that it has easier access to finance, talent, and land resources (Ho et al., 2002, pp. 330-341; Ramirez & Tan, 2004; Lim & Pang, 2016; Sally, 2015). In 1990, Singapore's SME sector was weaker than its East Asian counterparts in terms of value-add and share of exports (Table 3).

Just prior to 2000, local SMEs accounted for only 16% of total exports. This is compared to 56% in SME-intensive Taiwan, 42.4% in Korea, and 20% in Vietnam and 31.5% in India (OECD, 1997; Kim & Nugent, 1999; Badrinath., 1997). This means that local enterprises were not as globally competitive as their East Asian counterparts. Additionally, they only contributed 43% of the nominal value-added relative to non-SMEs (Department of Statistics, Singapore, 2021). Additionally, local enterprises, most of which are SMEs, contributed only 30% of the value-add relative to foreign enterprises in recent years (Department of Statistics, Singapore, 2019, 2020a, b). Singapore is today a high-income country, and comparisons with other high-income economies corroborate this. Significantly, in most high-income economies in the OECD, SMEs typically contribute about 55% of national GDP (OECD, 2004; Ayyagari et al., 2003).

Singapore's SMEs may also be compared with Hong Kong, though official statistics for the latter are scarce due to colonial administrators' refusal to collect data for fear of it being abused for interventionist purposes (Goodstadt, 2007). The leading estimate of Hong Kong's SME data by Richard Wong (1999) showed that in 1999, "SMEs accounted for 70.2% of the total employment of 1,796,635 people in nine (major) industries. Further, SMEs accounted for 61.9% out of the total value-added of HK\$523,025 million". If these figures are correct, it means that in 1999, SMEs in Hong Kong contributed more to their economy at 61.9% than Singaporean SMEs contributed to the Singapore economy in 2020 at 43%.³

The imbalance is also clearly reflected in innovation data. In Singapore, most innovation activities are carried out by the foreign sector, rather than by local enterprises. This is seen by the fact that historically, most of the patents registered in Singapore were not retained by local assignees, as well as the low contribution of local enterprises to overall R&D spending (Fig. 8).

³ Hong Kong SMEs are defined more narrowly and include only manufacturing firms with less than 100 staff and non-manufacturing firms with less than 50 staff, compared to Singapore's looser criteria of any firm that has up to 100m in annual revenue or less than 200 staff.

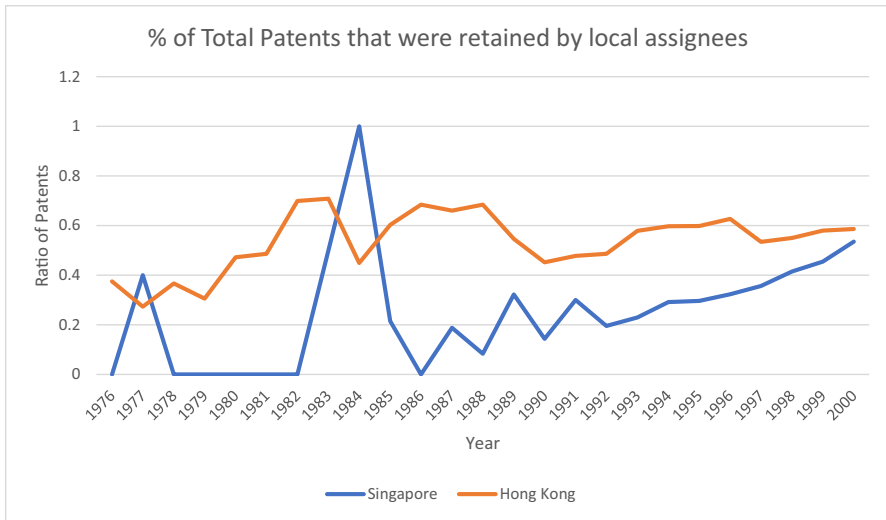


Fig. 8 Ratio of Total Patents Retained by Local Assignees (Comparison of Pre-2000 Singapore and Hong Kong). Source: United States Patent and Trademark Office (2020).

Based on the same patent data, we can see that for the pre-2000 period, there is a higher proportion of patents retained by local assignees, in Hong Kong than in Singapore. Local assignees are companies or individuals primarily resident in the respective country. In other words, in market-oriented, pre-2000 Hong Kong, where the state did not artificially engineer the local-foreign enterprise mix, local enterprises retain a larger share of patents registered. Singapore’s foreign-local disparity in patent performance is even starker when the most recent year, 2018, is isolated. A total of 79.79% of all private sector patents in Singapore applied for were by foreign entities instead of domestic ones (Appendix 2).

Analysis of R&D spending in Singapore also shows that it is skewed towards the state and MNCs. What we observe is that even though total R&D spending in Singapore is high and comparable to major developed countries, much of this is driven by foreign multinational corporations, who take up 75% of the total spending as compared to local enterprises (Appendix 3).

6.2.2 Attempts to reverse course by funding SME productivity projects

Recognising the unequal playing field that SMEs encountered in much of Singapore’s history, the government decided to reverse course. The key milestone is the implementation of the national SME 21 central plan, which for the first time in the government’s history, acknowledged that SMEs especially perform poorly on productivity, especially in terms of labour. It was believed that labour productivity is an important indicator since labour is a crucial resource, and since the bulk of labour was employed by SMEs, SMEs needed to now receive productivity-focused funding (SME 21 Plan, 2000). Hence, from 2000 onwards, the state directed its industrial policy towards improving labour productivity amongst local enterprises, a turning

Table 4 Brief Summary of Labour Productivity Targets and Achievements in Singapore

Year	Name of Plan	Expected Targets	Actual Results
1981	Economic Development Plan for the Eighties	6-8% per annum	4.4% per annum
2003	Economic Review Committee and SME 21	2-3% per annum	1% per annum
2010	Economic Strategies Committee	2-3% per annum	0.4% per annum (2010 to 2015)

Source: Author's compilation and calculations

point marked by the formation of SPRING (Standards, Productivity and Innovation Board), which targeted SMEs.

However, this attempt has been relatively unsuccessful, since labour productivity performance has fallen short of expectations, suggesting that SMEs remain weak. Poor productivity amongst local enterprises may be benchmarked against the government's own targets and comparable nations (Auyong, 2016; Low & Auyong, 2014). The poor performance is echoed by leading experts on Singapore productivity policies, Woon Kin Chung and Loo Ya Lee, who concluded that "Singapore's productivity performance has not been outstanding" (Woon & Loo, 2018, p. 10) (Table 4).

Besides looking at the government's own targets, Singapore's weak productivity performance can also be compared with other countries. Since 2000, when productivity-focused industrial policy was emphasised by the Singapore government, its labour productivity performance has lagged that of Hong Kong and Taiwan, in terms of changes in value-added per hour worked (Table 5).

6.2.3 Implications for economic adaptiveness

Singapore's over-reliance on foreign multinationals is not an economically sustainable strategy, especially if innovation is considered. Scholars have demonstrated that small firms are crucial in the innovation process. Though they may lack economies

Table 5 Changes in Value-Added per Hour Worked (%)

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	Average
Singapore	-4.1	6.1	4.8	6.5	2.3	2.1	-0.1	-7.5	-2.8	0.81
Hong Kong	-0.6	1.9	4.3	5.2	5.5	6.3	3.8	3.6	-0.4	3.29
Taiwan	NA	1.8	0.4	2.5	4.8	5.2	6.5	-0.6	1	2.7
Year	2011	2012	2013	2014	2015	2016	2017	2018	Average	
Singapore	4.2	-0.4	1.3	1.5	1	2.7	5.3	3.9	2.44	
Hong Kong	4.0	1.0	1.8	4.0	1.5	2.1	4.2	0.9	2.6	
Taiwan	4.0	0.9	2.0	3.9	0.5	4.4	3.7	2.5	2.74	

Sources: Ministry of Trade and Industry, Singapore (2011, 2012, 2013, 2014a, 2015, 2016, 2017, & 2018), Census and Statistics Department, HKSAR (2020), & National Statistics, Republic of China (Taiwan) (n.d.)

of scale and access to finance like large firms, they tend to be more dynamic, adaptable, and entrepreneurial (Baumol, 2004; Baumol et al., 2007). Some even go as far as to say that smaller firms in the US have exhibited more innovations per employee than larger ones (Acs & Audretsch, 1990; US Small Business Administration, 2006, p. 185). Singapore's enterprise mix, being skewed towards large MNCs, means that it does not reap the unique contributions of SMEs. The skewed strategy is also unsustainable given the footloose nature of global capital; MNCs may pull their investments anytime or retain the highest-value segments of the production process for themselves, minimising knowledge spillovers to the local economy. To achieve innovation-based growth requires a holistic approach where local enterprises also develop their innovation capacity, which Singaporean scholars suggest have not occurred (Wang, 2018; Lim, 2016).

Clarifications are warranted. First, there is no magical threshold of SMEs to strive for and second, there is no specific sectoral composition that is 'best'. Austrian economics establishes that the 'ideal market structure' is unknown *ex-ante*, and only emerges within the competitive process. The point being made here is *not* that 'more SMEs are better', even though SMEs do offer unique contributions. The argument is that because the Singaporean state decided to play a directive role, it has pre-committed the entire economy towards a specific growth path, making it difficult for it to change course. A market-based system, where the firm and market structure are not artificially engineered, is more adaptable to the uncertain landscape of innovation than industrial planning.

Crucially, the market process is a complex adaptive system (Lewis, 2017; Vaughn, 1999). The micro-level dynamic responses of entrepreneurs enable the larger economy to adapt to changing conditions, an especially important trait in the uncertain landscape of innovation. This is best demonstrated by Singapore's East Asian counterparts of Taiwan and Hong Kong, who preferred a 'facilitative' rather than 'directive' approach to entrepreneurship. The Austrian economist Tony Yu previously explored how adaptive Kirznerian entrepreneurship drove Hong Kong's development. While SMEs typically do not enjoy massive amounts of finance for R&D, these entrepreneurs engaged in small-scale tactics such as product imitation, subcontracting, spatial arbitrage, and diversification (Yu, 1998). The overall macro effect of Hong Kong's embrace of adaptive entrepreneurship is that it underwent a structural transformation, in a bottom-up fashion characteristic of the market process, from an agricultural economy to manufacturing in the 1950s, after which into services, finance and international trade (Yu, 1997). A similar story occurred in Taiwan, where small-scale Kirznerian entrepreneurs drove development (Yu & Yan, 2007). Despite humble beginnings, they used similar strategies as in Hong Kong, transforming the economy from agriculture to become a tech-intensive global player; by 2000, 15 of the top IT companies in the world were from Taiwan (Yu & Yan, 2007).

Singapore's aim to thrive as a knowledge-based economy requires greater adaptiveness, which is hindered by the state's fixation on a pre-determined path. While more research is needed, there is some concern of late regarding the dearth of knowledge-intensive services firms in the Singaporean economy. Manufacturing, a legacy of the developmental state's industrial policy and favouring of MNCs, continue to dominate the

Singapore economy rather than services (Department of Statistics, Singapore, 2020a, b). Singapore's continued focus on manufacturing and industry-intensive sectors by the government means that the structural adjustment towards services, which tend to be more significant in knowledge-based economies, is frustrated. Singapore economist Lim (2018) wrote that Singapore's 'comparative advantage' in manufacturing was artificially engineered, which would naturally give way to services if the state stopped propping up heavy industries. A study of Singapore's government investment in biotech also showed that the results were temporary, concentrated in only a few multinational firms, and did not lead to the knowledge spillovers as initially intended (Wong, 2011). Foreign firms, who drove most innovation activity, merely used Singapore as a low-cost production base. The resulting policy implication from these observations is that rather than betting on a certain industry or firm type, it is far better to allow the market process to discover the optimal enterprise mix and adapt to changing macro-conditions.

7 Conclusion

This article has sought to apply an Austrian lens to evaluate what industrial policy can and cannot achieve, through a case of Singapore, the country that has most extensively used industrial policy as a central economic strategy. Singapore has often been referred to as the "best-case scenario" where industrial policy was implemented intelligently with little negative side-effects. It thus provides a useful test case to evaluate industrial policy and its limits.

While I acknowledge the merits of arguments that have stressed the impossibility of successful development planning, I present a somewhat modest criticism of industrial policy that focuses on the unintended consequences generated by policymakers. While admittedly difficult and rare, industrial policy can foster genuine economic development as the Singapore developmental state has done, but this has come at the cost of lower innovation, productivity growth, and less private entrepreneurship. Singapore is admittedly not just a highly industrialised economy; it is one where consumers and residents have high living standards. Notwithstanding its achievements, however, the state-led approach to development nonetheless hampers the spontaneous market process necessary for bottom-up innovation. The entrepreneurial discovery of the market process is truncated by the large presence of industrial subsidies circulating in the economy which keeps firms dependent, rather than innovative. By crowding out indigenous entrepreneurs and siphoning capital to the state sector, the Singapore state has achieved a type of development that limits the productivity and innovation of SMEs, which in turn hampers the economic adaptiveness of the larger system.

The Singapore case is admittedly an outlier which may not apply to many other nations. The unique institutional framework of the developmental state was specifically designed to steer market forces in pre-determined directions without succumbing to the failures seen in regulatory states. Plausibly, egregious failures of industrial policy elsewhere are thus avoided due to its carefully structured institutional design. Nevertheless, the Singapore case is worth exploring since industrial policy advocates have held it up as an exemplar. As this paper has shown, caution in adopting Singapore's approach to development is warranted.

Appendix 1

Table 6 Comparison of Hong Kong and Singapore Patent Performance in Two Phases

Time Period in Phases	Year	Singapore				Hong Kong			
		Total Patents (A)	Local Assignees (B)	% of total patents that were retained by local assignees (C=B/A x 100%)	Foreign Assignees/ Unassigned	Total Patents (D)	Local Assignees (E)	% of total patents that were retained by local assignees (F=E/D x 100%)	Foreign Assignees/ Unassigned

	Singapore					Hong Kong																			
	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Early Phase (Market-Liberal Hong Kong institutional differences vis-a-vis Singapore are pronounced)	3	5	3	0	6	5	6	6	4	14	5	16	12	28	21	30	41	61	79	81	124	132	181	207	299
	0	2	0	0	0	0	0	3	4	3	0	3	1	9	3	9	8	14	23	24	40	47	75	94	160
	0.00%	40.00%	0.00%	NA	0.00%	0.00%	0.00%	50.00%	100.00%	21.43%	0.00%	18.75%	8.33%	32.14%	14.29%	30.00%	19.51%	22.95%	29.11%	29.63%	32.26%	35.61%	41.44%	45.41%	53.51%
	3	3	3	0	6	5	6	3	0	11	5	13	11	19	18	21	33	47	56	57	84	85	106	113	139
	24	33	30	36	53	70	73	65	78	73	117	100	114	143	164	222	173	197	238	276	273	292	411	442	560
	9	9	11	11	25	34	51	46	35	44	80	66	78	78	74	106	84	114	142	165	171	156	226	256	328
	37.50%	27.27%	36.67%	30.56%	47.17%	48.57%	69.86%	70.77%	44.87%	60.27%	68.38%	66.00%	68.42%	54.55%	45.12%	47.75%	48.55%	57.87%	59.66%	59.78%	62.64%	53.42%	54.99%	57.92%	58.57%
	15	24	19	25	28	36	22	19	43	29	37	34	36	65	90	116	89	83	96	111	102	136	185	186	232

	Singapore				Hong Kong			
	Year	Count	Percentage	Count	Count	Percentage	Count	Count
Later Phase (After HK's handover to China and when institutional differences vis-a-vis Singapore are diminished)	2001	388	53.35%	181	593	53.63%	318	275
	2002	533	49.34%	270	578	49.31%	285	293
	2003	564	44.68%	312	620	50.32%	312	308
	2004	589	42.61%	338	548	49.45%	271	277
	2005	466	44.64%	258	489	52.15%	255	234
	2006	587	44.46%	326	654	46.48%	304	350
	2007	547	46.07%	295	720	48.75%	351	369
	2008	571	44.13%	319	600	50.17%	301	299
	2009	622	43.25%	353	493	41.99%	207	286
	2010	827	45.10%	454	591	43.49%	257	334
	2011	891	48.71%	457	525	38.10%	200	325
	2012	1091	47.30%	575	565	45.13%	255	310
	2013	1102	50.54%	545	630	38.25%	241	389
	2014	1308	48.78%	670	624	40.06%	250	374
	2015	1368	47.66%	716	665	45.11%	300	365
	2016	1411	48.97%	720	702	47.86%	336	366
	2017	1482	41.50%	867	753	50.33%	379	374
	2018	1483	38.50%	912	804	46.89%	377	427
	2019	1668	39.39%	1011	893	50.17%	448	445

Source: United States Patent and Trademark Office (2020)

Appendix 2

Table 7 Private Sector Patents Applied by Enterprise Ownership and Industrial Classification for the Year 2018, Singapore

Industrial Classification	Local SMEs		Local LEs		Foreign Companies		Total
Primary Industries & Construction	12	85.71%	2	14.29%	0	0.00%	14
Biomedical Manufacturing	13	44.83%	0	0.00%	16	55.17%	29
Chemicals	0	0.00%	0	0.00%	4	100.00%	4
Electronics	9	4.00%	34	15.11%	182	80.89%	225
Precision Engineering	39	49.37%	0	0.00%	40	50.63%	79
Transport Engineering	9	14.75%	8	13.11%	44	72.13%	61
General Manufacturing	5	20.83%	0	0.00%	19	79.17%	24
(Total Manufacturing)	75	17.77%	42	9.95%	305	72.27%	422
R&D	220	73.83%	0	0.00%	78	26.17%	298
Financial Intermediation & Other Business Activities	37	35.92%	5	4.85%	61	59.22%	103
Education, Health, Social Services	5	100.00%	0	0.00%	0	0.00%	5
Information & Communications	26	55.32%	0	0.00%	21	44.68%	47
Logistics	0	0.00%	1	100.00%	0	0.00%	1
Wholesale & Retail Trade	15	1.11%	11	0.82%	1323	98.07%	1349
Other Services	2	100.00%	0	0.00%	0	0.00%	2
(Total Services)	305	16.90%	17	0.94%	1483	82.16%	1805
Total	392	17.49%	61	2.72%	1788	79.79%	2241

Source: National Research Foundation, Agency for Science, Technology and Research, Singapore (2019).

Appendix 3

Table 8 Private Sector R&D Expenditure by Enterprise Ownership/Size, Type of R&D and Field of Science and Technology for the Year 2018 (SGD Millions)

Field of Science and Technology	Local SMES			Local Larger Enterprises			Foreign Companies								
	Basic Research	Applied Research	Experiential Development	Basic Research	Applied Research	Experiential Development	Basic Research	Applied Research	Experiential Development						
	Total	Total	Total	Total	Total	Total	Total	Total	Total						
Agricultural & Food Sciences	12.93	8.88	7.02	28.83	11.09%	0	2.85	1.66	4.51	1.73%	17.59	103.42	105.69	226.7	87.18%
Biomedical & Related Science	65.17	17.44	65.04	147.65	30.88%	0	0	0.19	0.19	0.04%	53.81	111.29	165.24	330.34	69.08%
Engineering & Technology	65.99	121.82	273.73	461.54	10.99%	32.77	319.74	254.22	606.73	14.44%	524.88	878.32	1729.43	3132.63	74.57%
Natural Sciences (excluding Biological Sciences)	13.99	17.92	31.27	63.18	10.82%	64.19	19.07	29.1	112.36	19.24%	129.68	83.94	194.73	408.35	69.94%
Energy	3.9	7.18	0.08	11.16	42.02%	0	0.14	0.82	0.96	3.61%	0.55	10.5	3.39	14.44	54.37%

Field of Science and Technology	Local SMES				Local Larger Enterprises				Foreign Companies						
	Basic Research		Applied Research		Basic Research		Applied Research		Basic Research		Applied Research				
	Development	Total	Development	Total	Development	Total	Development	Total	Development	Total	Development	Total			
Other Areas	0.45	2.91	7.75	11.11	12.51%	0	9.94	0.36	10.3	11.60%	31.87	27.06	8.47	67.4	75.89%
Total	162.43	176.15	384.89	723.47	12.83%	96.96	351.74	286.35	735.05	13.04%	758.38	1214.53	2206.95	4179.86	74.13%

Source: National Research Foundation, Agency for Science, Technology and Research, Singapore (2019)

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